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Multi-facility Green Weber problem. (English) Zbl 07128387
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Summary: Locating facilities to satisfy the demands of customers is a strategic decision for a distribution system. In this article, we study the multi-facility green Weber problem (MF-GWP), an extension of the classical multi-facility Weber problem, that considers environmental concerns in a distribution system in the context of a planar facility location problem. In the MF-GWP, the vehicles are sent directly from the facilities to the assigned customers to satisfy their demands. Each customer has a deadline and the vehicles serving the customer must arrive at the location of the customer no later than the deadline. The MF-GWP determines the locations of p facilities on the plane, $p > 1$, allocations of customers to the facilities, and the speeds of the distribution vehicles so as to minimize the total amount of CO_2 emission in the distribution system. We formulate this problem as a mixed integer second order cone programming (MISOCP) problem. This formulation turns out to be weak and therefore only small size instances can be solved to optimality within four hours. For larger size instances, a local search heuristic is proposed and some well-known heuristics developed for the multi-facility Weber problem, namely "location-allocation", "transfer follow-up", and "decomposition" are adapted for the MF-GWP. We use second order cone programming (SOCP) and the proposed MISOCP formulation as subproblems within the heuristics. We provide our computational experiments to compare the proposed solution methods in terms of solution quality and time. The results show that within a fixed computational time, even though the location-allocation heuristic is able to make more replications, the improvement heuristics considered, i.e., transfer or transfer followed by decomposition, usually find better solutions while using less number of replications. We also investigate how the total amount of CO_2 emitted by distribution vehicles changes with respect to the number of facilities located. We argue that in several real life applications from different sectors including aviation and robotics, MF-GWP and its extensions or modifications can be used to reduce the CO_2 emission or energy consumption. As an illustrative example, we show the applicability of the MF-GWP within an assembly line system, where the stations are fed by dedicated rail-guided vehicles.

MSC:

90B Operations research and management science

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sustainability; continuous location; transportation; CO_2 emission; nonlinear optimization; matheuristics

Software:

CPLEX

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